Risk Factors for Surgical Site Infection in Elderly Patients Following Orthopedic Surgery

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A Mater's Paper submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Public health in the Public Health Leadership Program.

Chapel Hill

2004

Advisor

Second Reader

10/12/04

Date

Background:

SSI following orthopedic surgery adversely impacts the functional status and quality of life of elderly patients.

Objective:

To identify risk factors for SSI in elderly patients undergoing orthopedic surgery.

Methods:

A matched case-control study was conducted at 8 hospitals (1 tertiary care and 7 community hospitals). Cases (orthopedic patients > 64 years old with SSI) were prospectively identified between 6/1991-7/2002. Controls were operative patients > 64 years old who did not develop SSI. Controls were frequency matched to cases by type and year of procedure and by hospital. Variables studied included demographics, comorbid conditions, functional status, peri-operative and hospital risk factors. Independent relationships between variables and SSI were identified using conditional logistic regression.

Results:

169 SSI cases were identified and 171 controls were selected. The mean age of the cohort was 74.7 years. 66% of subjects were female and 83% were Caucasian. The most common procedures were hip arthroplasty (n=74, 21.8%), fracture repair (n=55, 16.2%) and knee arthroplasty (n=40, 11.8%). The most common SSI pathogen was *Staphylococcus aureus* (95/169, 56.1%; 52/95 [54.7%] were

methicllin-resistant). In multivariate analysis, admission from a long-term care facility was the only independent predictor of SSI (OR 4.40 95% CI 1.66 11.76). Among patients admitted from home (n=275, 80.9% of study patients), the only independent predictor of SSI was repeat surgery at the same site (OR 2.98, 95% CI 1.38, 6.44).

Conclusion:

Patients undergoing orthopedic surgery who are admitted from long term care facilities are at increased risk for SSI. Among patients admitted from home, those undergoing repeat surgery are at increased risk for SSI.

Background

Surgical site infections (SSI) are the most common type of nosocomial infection in surgical patients and are the third most common nosocomial infection in the United States, accounting for 14% to 16% of nosocomial infections (1). SSIs are a common complication of care, occurring in 2-5% of patients after clean extra-abdominal surgeries such as orthopedic surgery. SSIs can be classified as incisional and organ/space (9). Incisional infections are further separated into superficial (skin and subcutaneous tissue) and deep (deep soft tissue muscle and fascia). SSIs account for increased morbidity in affected patients, which extends hospital stay and increases the risk for death and hospital costs. An estimated 9,700 SSI-related deaths occur annually, with 3,250 directly attributed to SSI (2). Reportedly 325,000 SSIs occur each year in the United States, generating hospital costs in excess of $1 billion (2). A 1992 analysis demonstrated that each SSI prolonged length of stay seven to nine days and resulted in an added cost of $3,152 per infection (2). In particular, orthopedic SSIs extend total hospital stays of the general population by 2 weeks per patient, doubles re-hospitalization rates, and increase healthcare costs by more than 300%; this causes greater physical limitation and reduces quality of life (20).

Risk Factors

The National Nosocomial Infections Surveillance System (NNIS) basic risk index, developed in 1990 and since been validated (8, 9), utilizes certain risk variables to stratify patients undergoing surgery into four risk index groups. One risk point is assigned for the presence of each of the following: a surgical wound classified as either contaminated or dirty; an American Society of Anesthesiologists (ASA) preoperative assessment score of 3, 4, or 5; and an operation lasting longer than the 75th percentile of similar procedures performed in the US.

Wound class is subcategorized into four groups, clean, clean-contaminated, contaminated, and dirty (9). Several studies found a moderate correlation between the wound classification and the SSI rate: as a wound class changes form clean to dirty, there is an increasing incidence of bacterial contamination and subsequent incidence of postoperative infection (9, 23, 24, 25). Increased procedure duration is associated with an increased risk of wound infection and this risk is additional to that of the classification of operation (7, 9). The extended duration of an intervention may indicate the seriousness of the infection and complexity of the particular procedure. The ASA score is a preoperative measure of comorbid illness that is assigned to each patient (10). Generally, it is a measure of the patient's general health status based on the age of the patient and presence of co-morbidities at the time of surgery. Scores range from 1, a healthy person, to 5, a patient not expected to survive past 24 hours, with or without surgery. The NNIS risk index assigns one risk point to patients with an ASA > 2 (9). The ASA score has limitations due to its subjectivity and poor inter-reliability (11). In addition, the range of ASA scores is limited to 5 values and is sometimes not easily accessible or available (11). Despite these limitations, ASA score is a strong, consistent predictor of SSI. SSI rates increase in a step-wise fashion for each increase in the NNIS risk index strata. For example, in one study, the SSI rate was 1.5% for the zero point strata, 2.9% for one point, 6.8% for two point and 13% for the three point strata (9).

There are several additional known risk factors for SSI for the general population which involve a complex interaction of numerous variables. Examples of some of these risk factors include extremes of age (infants and older individuals), diabetes, obesity, cigarette smoking, systemic corticosteroids and malnutrition, pre-operative nasal carriage of *S. aureus*, presence of a remote focus of infection, and duration of preoperative hospitalization (26).

Several risk factors have been independently associated with SSI and specifically, SSI following orthopedic and neurosurgical procedures. Risk factors for SSI in spinal surgery include acute trauma, time between hospital admission and surgery, and increased postoperative intensive care unit stay (21). Another study found that morbid obesity, postoperative incontinence, posterior approach, and surgery for tumor resection were independent risk factors for SSIs following laminectomy and spinal fusion (22). Lastly, insertion of any prosthetic implant increases the risk of infection of the wound and surgical site (9). Though these risk factors were identified for the general population, they have important implications for the geriatric population, who constitute one-third of all operations (26). In addition, prior studies have been limited by small sample sizes and have been limited to a single institution.

Geriatric Surgical Population

The proportion of the population aged > 65 years is projected to increase from 12.4% to 19.6% by 2030, with the total number of elderly persons projected to increase from approximately 35 million to 71 million (4). Physicians admitted more than 12 million elderly patients to the hospital per year in the US in recent years; the number of hospitalized elderly patients is projected to double by 2030 (4). Furthermore, based on discharge data from hospitals in the US, the percentage of all surgical operations on patients greater than 65 years old increased from 19% in 1980 to 43% in 1998 (4).

Elderly individuals are at increased risk for acquiring infection compared to younger individuals, and once infected are more likely to have adverse outcomes, such as increased mortality, increased duration of hospitalization, decreased functional status, decreased activity levels and increased healthcare costs (5). Individuals aged > 65 have 3-5 fold higher health-care costs per capita than persons < 65 years of age (6). The elderly are at an increased risk for nosocomial infections due to immunosenescence, poor nutrition, multiple comorbidites, and impaired wound healing, and have more cognitive and functional disabilities when compared to younger individuals (5). Of all nosocomial infections among elderly patients, 11% are due to SSI (9). Despite the increasing proportion of elderly surgical patients and the devastating impact of SSIs on the clinical outcomes of elderly patients, few researchers have studied SSI in the elderly. SSIs following orthopedic surgery can be particularly devastating to the elderly by severely impacting functional status and activity, which can result in increased duration of hospitalization, and increased mortality

(28). Although retrospective reports of functional status before hospital admission are often used in studies and by clinicians caring for hospitalized patients, the validity of these reports has not been established (27). In general, not enough attention has been directed towards studying the relationships between functional status and SSI.

Purpose of Study

No studies have specifically studied risk factors for SSI following orthopedic procedures in elderly patients. Such studies are important, and will facilitate the design and implementation of effective interventions to prevent SSI in elderly orthopedic surgical patients. A better understanding of the risk factors associated with SSIs following orthopedic surgery in this population might help to improve efforts to improve the outcomes of elderly surgical patients. The objective of this study is to determine the risk factors for SSI in elderly patients undergoing orthopedic surgery.

Methods

Study Design and Setting

A nested case-control study was conducted at eleven hospitals located in North Carolina: ten from the Duke Infection Control Outreach Network (DICON) and also the Duke University Medical Center (DUMC). DICON includes 26 hospitals located in the southeastern United States with primary focus on hospital infection control programs and practices. Ten of these hospitals collected surgical data to the DICON operative database. SSI surveillance is conducted using the same definitions and methods at all study hospitals.

Case and Control Definitions

Cases for this study were defined as patients aged greater than 64 years who developed SSI after undergoing orthopedic surgery, defined as spinal fusion, knee replacement, hip replacement, laminectomy, fracture repairs, other types of joint procedures, and other types of musculoskeletal surgery. SSI was defined prospectively by infection control practitioners using standard CDC definitions (13). Information regarding identification of organisms was provided by the clinical microbiology laboratory at each hospital. Controls were surgical patients aged greater than 65 years who underwent an orthopedic surgical procedure and did not develop an SSI. Controls were frequency matched to cases by procedure type, year and hospital.

Data Collection

Data was abstracted from 1) the Duke Infection Control Outreach Network (DICON) database and 2) Duke University Medical Center (DUMC). These databases include data that was collected prospectively at the time of surgical procedure according to DICON guidelines. These factors included patient name, sex, age, race, surgical procedure, American Society of Anesthesiologists (ASA) score (10), wound class, length of procedure and National Nosocomial Infections Surveillance System (NNIS) risk index score (6). For patients who developed an SSI, additional data was collected including type of organism recovered.

Additional data was acquired by reviewing patients' medical records retrospectively. Data collected through chart review included race, marital status, insurance type, admission source, height, weight, comorbidities, Charlson score and McCabe score at the time of surgery, independence with activities of daily living at the time of surgery, immunosuppression and immunosuppressant use, post-operative glucose and number of days in hospital before surgery. Comorbid conditions, abstracted from ICD-9 diagnoses codes and from physician notes, included presence or absence of diabetes and related end organ damage, myocardial infarct, congestive heart failure, peripheral vascular disease, cerebral vascular accident, dementia, chronic obstructive pulmonary disease, connective tissue disease, peptic ulcer disease, hemiplegia, liver disease, renal disease and related dialysis, malignant neoplasm and metastasis, HIV, and organ transplant. The activities of daily living (ADLs) were used as a metric for functional status

The Charlson score is the cumulative score of the ICD-9 comorbid diagnoses (29). The Charlson Index contains 19 categories of comorbidity with an associated weight based on the adjusted risk of one-year mortality; the higher the score, the more severe the burden of comorbidity. The McCabe score was determined from comorbid conditions and stratified into non-fatal, ultimately fatal, or rapidly fatal (30). BMI was calculated from patient's charts as weight in kilograms divided by height in meters squared. The appropriateness of antibiotic prophylaxis was determined based on type of antibiotic, dosage, and timing of administration according to accepted guidelines.

Outcome variables of discharge disposition and death within one year of procedure were captured retrospectively from the patient chart.

Reliability

Investigators developed a standardized protocol to reduce variability in data collection. Investigators currently are performing a formal reliability study of data collection for key variables by comparing the data collected by the study nurse with the data collected by a second study nurse in a random sample of charts from the study sites. Agreement will be assessed using Kappa statistics. Items with poor (0-0.2) or fair (0.2-0.4) agreement was reviewed by two senior members and reasons for disagreements were determined. When necessary, procedures will be revised to improve the quality of the data collection. Reliability testing will be repeated for variables requiring revised procedures. With these measures internal consistency will be addressed.

Validity

The validity of data for key variables will be assessed according to the type of variable. Several variables have high accuracy because of standard measures and thus, will not be validated. Clinical variables will be validated using a clinical adjudication panel. The assessment of the panel will serve as the standard. Two senior members independently will review chart abstracts of randomly selected infected and uninfected patients and will assess the presence or absence of the clinical condition based on available data and clinical experience. Disagreements will be resolved by clinical consensus conference; if they are unable to agree on a specific issue, ultimate resolution will be reached by assessment by a third physician investigator. The panel assessment of the presence or absence of key variables will be compared to those of the study nurse and percent accuracy will be calculated. Items with less than 90% accuracy will be reviewed by senior investigators; reasons for inaccuracy will be determined; and procedures will be revised to improve the accuracy of data collection. Revised procedures will have validity testing repeated. For quality control measure, DICON investigators will review the accuracy of the study nurse's work throughout the study period by annual review of a random sample of 5% of study patients. In this manner, we will ensure content validity, construct validity, and criterion validity.

Statistical Analysis

Statistical programs used were SAS software (SAS Institute Inc, Cary, NC; version 8.1) and Microsoft Access. For continuous variables P values comparing differences between cases and controls were calculated using either the t-test for comparing the means of normally distributed variables or the Wilcoxon Rank Sum test for comparing the rank orders of other continuous variables. For dichotomous variables, P values were calculated using the Fischer's Exact test; and for ordinal variables with more than 2 levels, the chi-square test was used. Odds ratios were calculated for dichotomous variables.

Risk models were developed using logistic regression. Variables with a P value ≤ 0.25 in the bivariate analysis were included as candidate variables for the multivariate models, as were variables that were previously identified as SSI risk factors by other investigators. Candidate variables were grouped into a "candidate model". Final models were derived from the candidate model using a stepwise selection procedure and only variables with an adjusted P value <= 0.05 were included in the final models. Variables in derived models were checked for confounding. If the addition of a co-variable affected the beta-coefficient for the effect measure of a selected variable by more than 10%, the confounding variable was included in the model. All tests were 2-tailed, with $P \leq 0.05$ considered statistically significant.

Results

A total of 340 patients were enrolled in this study. 169 patients with SSI were identified and 171 uninfected controls were selected. The two most common orthopedic procedures were hip replacement (n = 74, 22%) and fracture repair (n = 55, 16%). The distributions of the procedure types were similar among patient groups.

Causative Agents

94% of patients with SSI had a pathogenic organism identified by culture (Table 1). Gram positive pathogens were the most common among this population. The most common causative pathogen for SSI was methicllin-resistant *Staphylococcus aureus*. (n = 52, 31%) followed by methicillin-sensitive *S. aureus* (n = 43, 25%) and coagulase-negative staphylococcus (n = 21, 12%). Seventeen percent (n=29) of infections were due to gram-negative organisms.

Most of the patients were female (n = 224, 66%). The mean age was 75 years (range 65-94). The largest ethnic group represented was Caucasian (n = 277, 83%). Patients tended to be married (n = 92, 46%) or widowed (n = 69, 35%). The mean BMI was 28 (range 15 - 55) with a normal, Gaussian distribution; nearly 35% of patients were obese.

Bivariate Analysis for SSI

Bivariate analysis comparing infected patients to frequency matched uninfected controls patients identified six variables that were significantly associated with SSI (Table 2). Being admitted from a long term care facilty was associated with an increased risk for SSI (Odds Ratio [OR] 4.85, 95% Confidence Interval [CI] 2.06, 11.42; $P < 0.001$). Infected patients were more likely to have been transferred from another hospital (OR 9.36, 95% CI 1.62, 54.13; $P = 0.004$). In terms of comorbid conditions, the presence of chronic obstructive pulmonary disease (COPD) was significantly more frequent in SSI patients than uninfected patients (OR 2.19, 95% CI 0.99, 4.86; $P = 0.05$). Cases and controls had a median Charlson score of 1 ($P = 0.051$). Charlson score greater than 3 was significantly more common among cases than in controls (11% vs. 3%) (OR 11.28, 95% CI 2.78, 45.76; $P < 0.001$). In terms of admission ADLs, cases were significantly more likely at preoperative baseline to require assistance in bathing (43% vs. 23%) (OR 3.62, 95% CI 1.93, 6.81; $P < 0.001$) and dressing (43% vs. 23%)(OR 3.34, 95% CI 1.81, 6.18; $P < 0.001$). Lastly, patients admitted on the same day of surgery were less likely to develop SSI (69% vs. 84%) (OR 0.42, 95% CI 0.24, 0.74; $P = 0.002$).

Multivariate Analysis

Logistic regression analysis included variables that were found to have with P-values < 0.25 by bivariate analysis and also variables with known association with SSI through prior literature review. Variables evaluated in multivariate analysis included marital status, severe arthritis (arthritis > 5), diabetes mellitus end organ damage, congestive heart failure, hepatic disease, renal disease, metastatic malignancy, the ability to feed oneself, immunosuppression, high ASA score (≥ 3), severe wound (≥ 3), redo procedure, and procedure time. Being admitted from a long term care facility was found to be the only independent significant predictor of SSI and was associated with decreased risk (OR 4.85, 95% CI 2.06, 11.42; $P < 0.001$.) (Table 3a). Because the majority of the study cohort (88%) was admitted from home, a model was developed including only patients who were admitted from home (Table 3b). In this secondary model, previous surgery at the same site as the current surgery (e.g. a "re-do" procedure) was found to be the only independent predictor of SSI, after controlling for the confounding effect of COPD (OR 2.98, 95% CI 1.379, 6.444; $P = 0.006$).

Outcome Factors

Cases were more likely to be discharged to a rehab facility (43% of cases), whereas controls most often were discharged to home (44% of controls) (Table 2). Cases were also more likely to be die one year after the procedure (17% vs. 4%) ($P < 0.001$).

Discussion

This was the first study to explore risk factors for SSI in elderly orthopedic patients. In addition, this study was one of the largest studies for orthopedic SSI risk factors ever performed. Through bivariate analysis, six factors were statistically associated with SSI: hospital admission from home, transfer from an outside hospital, the presence of chronic obstructive pulmonary disease (COPD), a Charlson score > 3, inability to bathe or dress oneself, and same-day surgery. Multivartiate analysis identified admission from a long term care facility as an independent risk factor for SSI, after controlling for the confounding effect of same-day admission. A second model restricted to home admission identified repeat surgery as a predictive variable, after controlling for the effect of COPD. These factors can help address the need for increased strategies for prevention of SSI in the elderly.

Several of the identified risk factors might be surrogate markers for poor health status. Patients living at home would be expected to be in better health than those who are residents of long term care facilities. Because these patients have improved preoperative health, they might have a decreased SSI risk. In this study, the Charlson score was shown to be predictive factors for increased SSI incidence; this agrees with prior reports (29). Moreover, COPD incidence was significantly higher in cases than in controls. COPD rates are increased with age and predispose the patient to a host of diseases, leading to poorer health outcomes and greater societal impact. In short, health status and surrogates of health status can be used to predict SSI rates to increase surveillance measures.

After developing a second model restricted including only patients admitted from home, repeat surgery at the same site increased the likelihood for SSI. This finding is consistent with prior reports (8, 18). Wimmer et al., in studying spinal surgeries in a retrospective study, identified history of prior operations as a significant risk for infection (18).

The ability to perform ADLs independently are important variables that should be studied as both risk factors and outcomes for infections in the elderly. Currently there is little in the literature describing the apparent relationship between the ADLs and SSIs. In the current study we identified in bivariate analysis that patients who required assistance in bathing and/or dressing were more significantly more likely to develop SSI. This study, to our knowledge, is the first study to examine ADLs as risk factors for SSI. In addition to increased rates of infection, loss of ADLs reflects a greater risk for hospitalizations and higher mortality rate. Moreover, assessment of a patient's ability to perform ADLs before their hospitalization would have good predictive value. These measures would potentially be a strong predictor of important health outcomes. In particular, among patients dependent in ADL function on hospital admission, these results highlight the prognostic importance of inquiring about the patient's functional status before the onset of the acute illness. With predictors based on functional ability, methods could later be developed to help improve health care for elderly surgical patients.

Surprisingly, obesity was not found to be independently associated with SSI, in contrast with previous reports (26). Obesity is expected to increase risk for SSI by a number of different mechanisms, such as decreased penetration of prophylactic antibiotics into adipose tissue, increased likelihood of poorly controlled serum glucose, increased colonization of the skin with bacteria with associated difficulty in skin antisepsis at the time of surgery and in the postoperative period, and impaired wound healing after surgery (31). The reason for the disparate results in the current study are unclear but might reflect the relative decreased importance of obesity as a SSI risk factor in the elderly as opposed to other risk factors which might be more common in the elderly surgical population.

Limitations

As a retrospective case-control study, there is potential sample, selection, measurement and misclassification bias. Sample bias was controlled for by selecting a comparable hospital control group representative of the source population for cases. Selection bias was addressed by using a trained research nurse who utilized standard surveillance criteria for retrospective data collection. In addition, controls were randomly selected using specific, objective criteria and were frequency matched on important potentially confounding variables. Measurement bias was reduced by using uniform criteria for data ascertainment for cases and controls. Occult SSI may have occurred in controls, leading to the misclassification of cases as controls. However, this type of misclassification would most likely lead to an underestimate of the association between a given risk factor and risk for SSI, and would not falsely identify a variable as a risk factor. Lastly, study subjects were selected from tertiary care and community hospitals residing in North Carolina; results from this study may not be generalizable to populations in other geographic areas. These limitations were recognized and accounted for where appropriate.

Strengths

This was a large, multi-center study that included 10 hospitals within a large and unique infection surveillance network of tertiary care and community hospitals. Cases were and much of the study data were identified and collected prospectively. Testing to assure reliability and validity of study data is underway. Multiple measures of comorbid conditions were used. This is the one of the largest studies to examine risk factors for SSI following orthopedic surgery and the first study to examine risk factors in elderly patients following orthopedic surgery.

Summary

This study provides important information that can be used to help target patients at high risk for SSI and to help implement interventions to prevent orthopedic SSIs in the geriatric population. In this study, both bivariate and multivariate analyses were used to identify risk factors for SSI in the geriatric population. The risk for and the impact of SSIs in the geriatric population are important problems that have been understudied. The relationships between functional status and nosocomial infections have not been extensively studied in prior studies in the elderly, and this study is the first to critically analyzed functional status as risk factor for SSI. This project also addresses key patient safety issues for hospitalized geriatric patients. The study data is useful for hospital epidemiology knowledge and clinical decision making, for designing intervention studies, for identifying patients to target for interventions, and as a foundation for future work.

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Table 1. Frequency of Organisms Cultured From the 169 Surgical Site Infections

Organism	**Number of Infections (n=169)**	**(% of all infections)**
Methicillin Resistant *Staphylococcus aureus*	52	30.8%
Methicillin Susceptible *Staphylococcus aureus*	43	25.4%
Coagulase negative *Staphylococci*	21	12.4%
Other Gram Positives	22	13.0%
Escherichia coli	7	4.1%
Other Gram Negatives	22	13.0%
Other Organisms	2	1.2%

Table 2. Bivariate Analysis Results for Risk Factors for Surgical Site Infection (SSI)

Variable	Cases (n=169)	Controls (n=171)	OR (95% Confidence Interval)	P-value
DEMOGRAPHICS				
Age, mean (standard deviation)	74.91 (6.38)	74.51 (7.09)		0.58
Sex				
Female, n (%)	111 (66)	113 (66)	1.02 (0.63, 1.63)	0.95
Male n (%)	58 (34)	58 (34)		
Race				
White, n (%)	137 (82)	140 (84)		
Black, n (%)	27 (16)	23 (14)		
Asian, n (%)	1 (1)	1 (1)		
Hispanic, n (%)	1 (1)	0 (0)		
Other, n (%)	0 (0)	1 (1)		
Unknown, n (%)	1 (1)	2 (1)		
Race (White vs. Non-White)				
White, n (%)	137 (82)	140 (84)	0.85 (0.48, 1.52)	0.58
Non-White, n (%)	30 (18)	27 (16)		
Marital Status				
Single never married, n (%)	7 (7)	10 (10)		
Married, n (%)	42 (42)	50 (50)		
Widowed, n (%)	41 (41)	28 (28)		
Divorced, n (%)	0 (0)	1 (1)		
Not reported, n (%)	5 (5)	5 (5)		
Unknown, n (%)	6 (6)	6 (6)		
Married				
Yes, n (%)	53 (56)	44 (47)	0.68 (0.37, 1.22)	0.18
No, n (%)	42 (44)	50 (53)		
Insurance				
Medicare, n (%)	157 (97)	156 (95)		
Medicaid, n (%)	0 (0)	3(2)		
Private Insurance, n (%)	5 (3)	6 (4)		
No Insurance, n (%)	0 (0)	0 (0)		
Medicare				
Yes, n (%)	157 (97)	156 (95)	1.62 (0.53, 4.95)	0.39
No, n (%)	5 (3)	9 (5)		
Admission Source				
Home, n (%)	121 (81)	154 (96)		
Nursing Home, n (%)	15 (10)	4 (2)		

Rehab Facility, n (%)	3 (2)	1 (1)		
Other Hospital, n (%)	11 (7)	2 (1)		
Prison, n (%)	0 (0)	0 (0)		
Admitted from long term care facility				
Yes, n (%)	29 (19)	7 (4)	4.85 (2.06, 11.42)	**<0.001**
No, n (%)	121 (81)	154 (96)		
Transfer from Outside Facility				
Yes, n (%)	11 (7)	2 (1)		
No, n (%)	139 (93)	159 (99)	9.36 (1.62, 54.13)	**0.004**
GENERAL HEALTH				
BMI, mean (standard deviation)	28.33 (6.41)	28.29 (6.70)		
Obesity				0.957
Yes, n (%)	52 (36)	50 (34)		
No, n (%)	93 (64)	99 (66)	1.17 (0.68, 2.02)	0.56
Arthritis				
1, n (%)	35 (21)	47 (27)		
2, n (%)	7 (4)	2 (1)		
3, n (%)	14 (8)	16 (9)		
4, n (%)	10 (6)	14 (8)		
5, n (%)	103 (61)			
Arthritis > 5				
Yes, n (%)	103 (61)	92 (54)		
No, n (%)	66 (39)	79 (46)	0.72 (0.45, 1.14)	0.16
Comorbidity				
Diabetes				
No, n (%)	147 (87)	144 (84)		
Yes, n (%)	22 (13)	27 (16)	0.69 (0.36, 1.33)	0.28
End Organ Damage from Diabetes				
No, n (%)	166 (98)	171 (100)		
Yes, n (%)	3 (2)	0 (0)	7.05 (0.61, 81.19)	0.08
MI				
No, n (%)	154 (91)	150 (88)		
Yes, n (%)	15 (19)	21 (12)	0.73 (0.37, 1.44)	0.84
CHF				
No, n (%)	150 (89)	160 (94)		
Yes, n (%)	19 (11)	11 (6)	1.90 (0.83, 4.34)	0.12
PVD				
No, n (%)	151 (89)	160 (94)		
Yes, n (%)	18 (11)	11 (6)	1.59 (0.73, 3.43)	0.22
CVA				

No, n (%)	156 (92)	164 (96)		
Yes, n (%)	13 (8)	7 (4)	1.74 (0.68, 4.46)	0.23
Dementia				
No, n (%)	161 (95)	164 (96)		
Yes, n (%)	8 (5)	7 (4)	1.31 (0.43, 3.98)	0.63
COPD				
No, n (%)	149 (88)	161 (94)		
Yes, n (%)	20 (12)	10 (6)	2.19 (0.99, 4.86)	**0.05**
Connective Tissue Disease				
No, n (%)	161 (95)	167 (98)		
Yes, n (%)	8 (5)	4 (2)	2.16 (0.62, 7.47)	0.21
Peptic Ulcer Disease				
No, n (%)	152 (90)	152 (89)		
Yes, n (%)	17 (10)	19 (11)	0.91 (0.46, 1.82)	0.79
Hemiplegia				
No, n (%)	168 (99)	171 (100)		
Yes, n (%)	1 (1)	0 (0)	4.20 (0.12, 151.97)	0.32
Liver Disease				
No, n (%)	166 (98)	171 (100)		
Yes, n (%)	3 (2)	0 (0)	5.61 (0.64, 49.35)	0.06
Renal Disease				
No, n (%)	158 (93)	167 (98)		
Yes, n (%)	11 (7)	4 (2)	2.88 (0.83, 9.94)	0.09
Dialysis				
No, n (%)	169 (100)	170 (99)		
Yes, n (%)	0 (0)	1 (1)	0.24 (0.01, 8.62)	0.32
Malignancy				
No, n (%)	149 (88)	153 (89)		
Yes, n (%)	20 (12)	18 (11)	1.15 (0.59, 2.25)	0.68
Metastatic Disease				
No, n (%)	166 (98)	171 (100)		
Yes, n (%)	3 (2)	0 (0)	3.79 (0.51, 28.27)	0.08
HIV				
No, n (%)	169 (100)	171 (100)		
Yes, n (%)	0 (0)	0 (0)		1
Transplant				
No, n (%)	169 (100)	171 (100)		
Yes, n (%)	0 (0)	0 (0)		1
Charlson Comorbodity Score				
0, n (%)	69 (41)	84 (49)		
1, n (%)	38 (22)	38 (21)		

2, n (%)	31 (18)	32 (18)		
3, n (%)	13 (8)	15 (8)		
4, n (%)	11 (7)	3 (2)		
5, n (%)	2 (1)	0 (0)		
6, n (%)	2 (1)	0 (0)		
7, n (%)	3 (2)	0 (0)		
Charlson Score, Median (Interquartile range)	1 (0,2)	1 (0,2)		
Charlson Score ≤ 3				0.051
Yes, n (%)	151 (89)	168 (98)		
No, n (%)	18 (11)	3 (2)	11.28 (2.78, 45.76)	**<0.001**
Admission ADL				
Ambulate				
No, n (%)	69 (45)	81 (51)		
Yes, n (%)	86 (55)	77 (49)	1.30 (0.79, 2.15)	0.3
Bathing				
No, n (%)	89 (57)	123 (77)		
Yes, n (%)	66 (43)	36 (23)	3.62 (1.93, 6.81)	**<0.001**
Dressing				
No, n (%)	89 (57)	122 (77)		
Yes, n (%)	66 (43)	37 (23)	3.34 (1.81, 6.18)	**<0.001**
Bowel Continence				
No, n (%)	153 (98)	147 (97)		
Yes, n (%)	3 (2)	4 (3)	1.44 (0.33, 6.34)	0.61
Urinary Continence				
No, n (%)	146 (97)	147 (94)		
Yes, n (%)	5 (3)	9 (6)	0.65 (0.22, 1.95)	0.43
Feeding				
No, n (%)	138 (90)	151 (96)		
Yes, n (%)	15 (10)	7 (4)	2.39 (0.91, 6.27)	0.06
McCabe Score				
1: Rapidly fatal, n (%)	2 (1)	2 (1)		
2: Ultimately fatal, n (%)	19 (12)	15 (9)		
3: Non-fatal, n (%)	137 (87)	145 (90)		
McCabe Rapidly Fatal				
Yes, n (%)	2 (1)	2 (1)		
No, n (%)	156 (99)	160 (99)	1.00 (0.14, 7.10)	1
Immunosuppresant				
None, n (%)	142 (89)	148 (94)		
Steroid, n (%)	12 (8)	9 (6)		
Non-Steroid, n (%)	2 (1)	1 (1)		

Steroid + Non-Steroid, n (%)	3 (2)	0 (0)		
Immunosuppresed				
Yes, n (%)	17 (11)	10 (6)		
No, n (%)	142 (89)	148 (94)	1.97 (0.83, 4.66)	0.12
NOSOCOMIAL				
ASA score				
1, n (%)	0 (0)	1 (1)		
2, n (%)	66 (39)	83 (49)		
3, n (%)	94 (56)	82 (48)		
4, n (%)	9 (5)	5 (3)		
ASA level ≥ 3				
Yes, n (%)	103 (61)	87 (51)		
No, n (%)	66 (39)	84 (49)	1.51 (0.96, 2.36)	0.06
Wound Class				
1: Clean, n (%)	149 (88)	163 (96)		
2: Clean-contaminated, n (%)	14 (8)	5 (3)		
3: Contaminated, n (%)	4 (2)	0 (0)		
4: Dirty, n (%)	2 (1)	2 (1)		
Wound Class ≥ 3				
Yes, n (%)	6 (4)	2 (1)		
No, n (%)	163 (96)	169 (99)	3.00 (0.56, 16.11)	0.16
Pre-Operative Antibiotic				
Given correctly, n (%)	107 (71)	104 (69)		
Not given correctly, n (%)	44 (29)	46 (31)	1.18 (0.69, 2.00)	0.55
Type Of Surgery				
Spinal Fusion, n (%)	20 (11)	19 (11)		
Fracture, n (%)	28 (16)	27 (16)		
Hip replacement, n (%)	35 (20)	39 (23)		
Knee replacement, n (%)	20 (11)	20 (12)		
Laminectomy, n (%)	22 (12)	22 (13)		
Other Surgery on musculoskeletal system, n (%)	22 (12)	22 (13)		
Other joint, n (%)	22 (12)	22 (13)		
Repeat Procedure				
No, n (%)	128 (81)	146 (88)		
Yes, n (%)	30 (19)	19 (12)	1.71 (0.92, 3.18)	0.07
Days Before Surgery, mean (standard deviation)	0.67 (1.51)	0.50 (2.53)		
Same day				
No, n (%)	53 (31)	27 (16)		
Yes, n (%)	116 (69)	143 (84)	0.42 (0.24, 0.74)	**0.002**
Procedure Time, mean	130.51	124.03		

(standard deviation)	(111.35)	(136.74)		
Procedure Duration greater than NNIS time				0.633
No, n (%)	111 (72)	128 (75)		
Yes, n (%)	44 (28)	42 (25)	1.19 (0.67, 2.11)	0.54
Post-op glucose, mean (standard deviation)	149.34 (46.77)	160.07 (57.91)		
OUTCOME				0.16
Discharge Disposition				
Home, n (%)	45 (29)	71 (44)		
Home Health, n (%)	21 (14)	24 (15)		
Rehab Facility, n (%)	66 (43)	54 (33)		
Nursing Home, n (%)	17 (11)	12 (7)		
Death, n (%)	4 (3)	1 (1)		
Other, n (%)	0 (0)	1 (1)		
Other Hospital, n (%)	1 (1)	0 (0)		
AMA, n (%)	0 (0)	0 (0)		
Death w/ one year of procedure				
Yes, n (%)	28 (17)	7 (4)		
No, n (%)	141 (83)	164 (96)	4.66 (1.90, 11.39)	**<0.001**

Table 3a. Multivariate Analysis Results for Risk Factors for Surgical Site Infection*

Factor	OR (95% Confidence Interval)	P-value
Admission from long term care facility	4.85 (2.06, 11.42)	**<0.001**

*Controlled for the confounding effect of same-day surgery

Table 3b. Multivariate Analysis Results for Risk Factors for Surgical Site Infection, Model Restricted to Patients Admitted from Home*

Factor	OR (95% Confidence Interval)	P-value
Repeat Surgery	2.98 (1.38, 6.44)	**0.006**

*Controlled for the confounding effect of chronic obstructive pulmonary disease